

Comparison of soil properties on slopes under different land use forms

Pető, Á.¹ – Bucsi, T. – Centeri, Cs.

¹Department of Nature Conservation and Landscape Ecology, Institute of Environmental and Landscape Management, Szent István University, Páter Károly u. 1., Gödöllő 2103, Hungary. Tel.: +36/28-522-000; Fax: +36/28-410-804; E-mail: Peto.Akos@mkk.szie.hu

1. Abstract

Water erosion is a natural process and occurs on almost every open-air field. In, close-to-natural conditions soil degradation and soil formation reaches its climax, reflecting the environmental factors of a certain area. In case we start agricultural production, forest and pasture or meadow management on an area, the threat of accelerated soil erosion occurs, thus the rate of soil degradation will exceed the rate of soil formation. In our study we have chosen slopes with pairs of contrasting land use (e.g. arable land with forest or arable land with meadow or meadow with forest etc.) where the slope length and angle are similar under the different land use types. For methods we chose the methodology of the Hungarian Soil Information Monitoring System and took soil samples from the upper and from the lower third of the slopes in order to compare the soil properties on these slope tiers. We performed laboratory measurements of basic soil parameters (e.g. pH [H₂O and KCl], SOM, P₂O₅, K₂O, CaCO₃ etc.). A good example of the results is with phosphorus because this is one of the best indicator for analysing the effect of water erosion as it is connected with the soil particles, so it is washed towards the lower slope tier together with soil aggregates in case water erosion occurs. According to our measurements, the amount of the P₂O₅ is 2,6–680,3% more on the lower slope tier. In general, the measurements provide help for farmers to reduce nutrient loss (save fertilizer), hold the nutrient at right place and thus provide their crop with the necessary amount of nutrients to reach better yields, and this way they save the purity of surface water and use the environment considerate.

2. Introduction

Soil erosion considered as serious problem on agricultural fields mostly in the humid tropics (Babalola *et al.* 2007, Acharya *et al.* 2007). The average precipitation of Hungary remains much lower than 1000 mm/year, the average in the hilly areas is between 600 and 800 mm/year. Even in these circumstances we can find high amount of soil and nutrient loss, severe erosion causing gully and rills (Pottyondy *et al.* 2007, Kertész and Centeri 2006, Bádonyi 2006, Jakab and Szalai 2005, Várallyay 2007). The structure of crop rotations do not favour soil protection (Faucette *et al.* 2007), contains big number of medium or low soil protection crop (Barczy *et al.* 1997, Centeri 2002). Tillage practices cause big amount of soil loss. Soil and nutrient loss, runoff and sediment yield calculations (Jakab and Szalai 2005) are important in protecting our valuable arable lands. Examination of soil parameters are essential to teach farmers for better management practices in order to save nutrients, soils, money, time and to protect the environment (Visser and Sterk 2007). Soil and nutrient loss are calculated in erosion models all over the world (Evelpidou 2006, Gournellos *et al.* 2004), especially in connection with arable cultivation (Hedin *et al.* 1995, Davidson *et al.* 2004). Reduced soil fertility and subsequent reduction in plant growth lead to reduced canopy and soil cover, worse plant conditions and possible increase of weed species. In our work we show differences of sediment quality based on shallow drillings and deep soil profile descriptions on two remote areas.

3. Materials and methods

Laboratory experiments

The amounts of AL-P₂O₅, AL-K₂O, soil organic matter (SOM), pH (KCl and H₂O), CaCO₃ and soil organic matter content were measured. Laboratory experiments were done according to the regulations at the Szent István University, Department of Nature Conservation and Landscape Ecology. In case of comparison of drillings samples are from a point source, while in case of the slope thirds, samples are average samples.

On-the-field pedological experiments

Different slopes sections were chosen for investigation in the Maglód area (*Figure 1.*). The slope angles were in the category of 5-12% on the lower slope and in the category of 12-17% in the upper slope. Soils were examined in situ by full soil profile descriptions (depth of layers, pH, color, soil physical type, carbonate content, soil types were determined).



Figure 1 Pedological investigation of the colluvium on the lower third of the slope near Maglód, Hungary

Cultivation both at the Galga and Maglód site were down the slope with maize, sunflower and winter wheat dominancy in the crop rotation. Whilst the Galga site is still in agricultural use, the territory near Maglód has been abandoned (*Figure 1.*), therefore it can be characterised as an abandoned plough-land.

4. Results

The measurements on two arable foothills proved the humic layer to be 2,4 (Maglód) and 2,6 meters (Galgahévíz) deep. Basic soil parameters on the low or no erosion zone of the slopes can be seen in *Table 1.* These serve as background parameters measured from samples deriving from control profiles.

Table 1 Results of the pedological laboratory analysis of the less eroded control areas

Settlement	Depth (cm)	Texture	pH		CaCO ₃ (%)	SOM* (%)	AL-P ₂ O ₅ (mg kg ⁻¹)	AL-K ₂ O (mg kg ⁻¹)
			H ₂ O	KCl				
Maglód	0-20	sandy loam	8.1	7.4	1.33	3.83	86.4	194.7
Galgahévíz	0-20	clayey loam	8.0	7.0	4.9	2.67	1767.3	199.3

*SOM = Soil Organic Matter

The upper 0-20cm layer in the Maglód area is more sandy, pH is higher, CaCO₃ content is smaller, SOM content is higher, AL-P₂O₅ content is significantly smaller, while AL-K₂O content is similar to the similar 0-20 cm uppermost layer of Galgahévíz.

Laboratory analyses of every 20cm layers of the 0-260 cm (Maglód) and the 0-240 cm (Galgahévíz) depth are shown in *Table 2* and *Figures 2* and *3.*

Soil did not differ in the examined layers, pH(H₂O) ranged from 8.1-8.6 in the Maglód area and 7.7-8.5 in the Galgahévíz area, while pH(KCl) ranged from 7.3-7.9 in the Maglód area and 7.2-8.2 in the Galgahévíz area. We can state that the lower and upper limits and the distribution of the pH most of the times reflect the amount of measured CaCO₃ content (ranges from 0-14.4 in Maglód and 0.8-7.3 in Galgahévíz).

There was a big difference between the distributions of the soil organic matter (SOM) content on the two examined areas. In Maglód the lowest SOM is 2.3 % while in Galgahévíz SOM reduces to zero level in some layers (at the depth of 140-160 and 160-180 cm). This number proves the Galgahévíz area to be more disturbed, more affected by the combined effect of tillage and natural soil erosion processes. This can be explained by the differences in the slope angle and length. The examined slope of the Galgahévíz area is much steeper and shorter than that in Maglód.

There was a big difference between the nutrient distributions of the two areas (*Figure 2.* and *3.*). In the upper 0-20cm layer the AL-P₂O₅ content is 10 times more at the Galgahévíz site because of the more intensive

fertilizing activity. The nutrient content of the examined layers varies greatly, no certain trend can be seen. It is the affect of the soil management, wind, water and tillage erosion.

Table 2 Results of the pedological laboratory analysis at the Maglód (M*) and Galgahévíz (G*) sites

Depth (cm)	pH				CaCO ₃		SOM*		AL-P ₂ O ₅		AL-K ₂ O	
	H ₂ O		KCl		(%)		(%)		(mg kg ⁻¹)		(mg kg ⁻¹)	
	M	G	M	G	M	G	M	G	M	G	M	G
0-20	8.2	8.1	7.5	7.4	3.3	4.9	5.1	2.0	175.7	1767.0	273.6	199.0
20-40	8.2	8.1	7.5	7.2	2.4	1.3	3.8	2.6	126.9	1266.0	215.0	383.0
40-60	8.2	7.7	7.5	7.2	1.3	1.3	3.5	5.4	77.1	1283.0	186.6	430.0
60-80	8.2	8.0	7.5	7.2	0.4	1.1	3.5	2.4	79.0	1371.0	184.1	272.0
80-100	8.2	8.0	7.6	7.2	0.0	0.8	2.3	1.7	79.0	1540.0	173.2	294.0
100-120	8.2	7.9	7.5	7.2	0.0	1.0	2.7	1.8	66.4	1304.0	185.8	392.0
120-140	8.1	8.3	7.3	7.6	0.0	1.0	2.7	1.3	73.2	392.0	187.4	407.0
140-160	8.5	8.2	7.7	7.5	14.4	1.2	4.3	0.0	109.3	660.0	159.0	424.0
160-180	8.3	8.4	7.6	7.7	6.1	2.1	2.8	0.0	92.4	669.0	153.1	478.0
180-200	8.4	8.5	7.6	7.8	11.8	3.4	3.0	0.3	111.5	1012.0	136.6	438.0
200-220	8.6	8.5	7.9	8.0	13.5	6.1	3.3	0.8	155.7	863.0	64.0	329.0
220-240	8.4	8.5	7.7	8.2	4.67	7.29	2.01	1.01	98.4	895.0	126.0	246.0
240-260	8.4	ND	7.7	ND	2.59	ND	2.23	ND	78.3	ND	133.7	ND

* LT = lower third of the slope, SOM = Soil Organic Matter, M = Maglód, G = Galgahévíz, ND = data not available

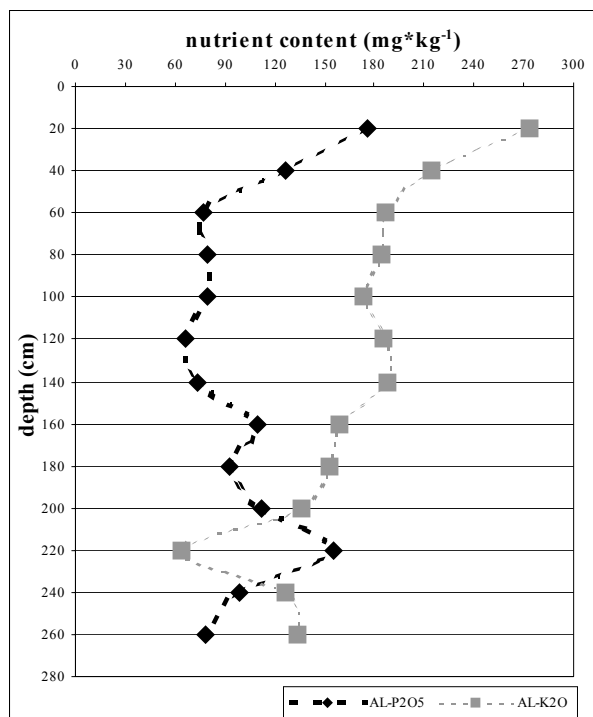


Figure 2 Vertical distribution of the phosphorous and potassium along the examined profile at the Maglód site

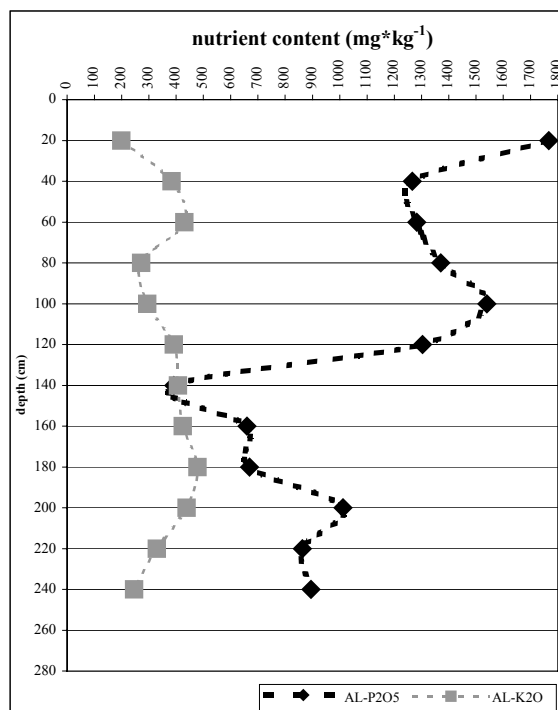


Figure 3 Vertical distribution of the phosphorous and potassium along the examined profile at the Galgahévíz site

Following table below (*Table 3.*) demonstrates the differences between the examined soil properties at the both sites. The comparison has been done between the topsoil parameters of the hilltop (less eroded area) and the lower slope territories. In both cases, results of samples deriving from the topsoil (0-20 cm) are compared. The row 'n' shows the absolute difference, whilst underneath it the change – usually the growth – is expressed in percentages.

As it is obvious from the results, the biggest changes, the most extreme growth at Maglód site was detectable in the carbonate percentages (~150%) and in the phosphorous content (~103%). In opposite the lime content did not change so dramatically at the Galgahévíz site (7%), though we could identify a more extreme growth in the phosphorous (~115%) content.

Table 3 Differences between top-soil properties on the plateau and at the lower third of the slope

Maglód site: hilltop samples – lower slope samples comparison							
		pH		CaCO₃	SOM*	AL-P₂O₅	AL-K₂O
		H₂O	KCl	(%)	(%)	(mg kg⁻¹)	(mg kg⁻¹)
difference	n	0.14	0.04	2.00	1.29	89.30	78.85
	%	1.75	0.54	150.38	33.68	103.36	40.49
Galga site: hilltop samples – lower slope samples comparison							
		pH		CaCO₃	SOM*	AL-P₂O₅	AL-K₂O
		H₂O	KCl	(%)	(%)	(mg kg⁻¹)	(mg kg⁻¹)
difference	n	0.30	0.50	0.53	0.20	947.10	13.10
	%	3.85	7.25	7.00	9.09	115.51	7.05

* SOM = Soil Organic Matter

In both cases, cultivation has been done ‘down the slope’, which affected soil properties in a special manner. On the basis of the measurements it is easy to see that not only plant nutrients have moved down the slope, but a special (re)distribution of the subjected soil properties appeared. Both at the Galgahévíz and Maglód sites, the vertical trends (Figure 2. and 3.) of plant nutrients in the 260 cm-s deep profile shows an unequal distribution and colluvial processes.

5. References

- Acharya G.P., McDonald M.A., Tripathi B.P., Gardner R.M., Mawdesley K.J., 2007. Nutrient losses from rain-fed bench terraced cultivation systems in high rainfall areas of the mid-hills of Nepal. *Land Degradation & Development*, 18 (5): 486-499.
- Babalola O., Oshunsanya S.O., Are K., 2007. Effects of vetiver grass (*Vetiveria nigriflora*) strips, vetiver grass mulch and an organomineral fertilizer on soil, water and nutrient losses and maize (*Zea mays*, L) yields. *Soil & Tillage Research*, 96 (1-2): 6-18.
- Barczy, A., Penksza, K., Czinkota, I., Néráth, M., 1997. A study of connections between certain phytoecological indicators and soil characteristics in the case of Tihany peninsula. *Acta Botanica Hungarica*, 40: 3-21.
- Bádonyi K., 2006. A hagyományos és a kímélő talajművelés hatása a talajerózióra és az élővilágra (Effects of conventional and conservation tillage on soil erosion and ecosystem). *Tájökológiai Lapok*, 4 (1): 1-16.
- Centeri, Cs., 2002. The role of vegetation cover in soil erosion on the Tihany Peninsula. *Acta Botanica Hungarica*. 44 (3-4): 285-295.
- Davidson, E.A., Neill, C., Krusche, A.V., Ballester, V.V.R., Markewitz, D., de O. Figueiredo, R., 2004. Loss of nutrients from terrestrial ecosystems to streams and the atmosphere following land use change in Amazonia. *Ecosystems and Land Use Change*, Geophysical Monograph Series 153, American Geophysical Union
- Faucette L.B., Governo J., Jordan C.F., Lockaby B.G., Carino H.F., Governo R., 2007. Erosion control and storm water quality from straw with PAM, mulch, and compost blankets of varying particle sizes *Journal of Soil and Water Conservation*, 62 (6): 404-413.
- Eveldidou, N., 2006. Using Fuzzy logic to map soil erosion. A case study from the island of Paros. *Tájökológiai Lapok*, 4 (1): 103-113.
- Gournellos, Th., Eveldidou, N., Vassilopoulos, A., 2004. Developing an Erosion risk map using soft computing methods (case study at Sifnos island), *Natural Hazards* 31 (1): 39-61.
- Jakab, G., Szalai, Z., 2005. Barnaföld erózióérzékenységének vizsgálata esőztetéssel a Tetves-patak vízgyűjtőjén (Erodibility measurements in the Tetves catchment using rainfall simulator). (In Hungarian with English abstract). *Tájökológiai Lapok (Hungarian Journal of Landscape Ecology)*, 3 (1):177-190.
- Hedin, L.O., Armesto, J.J., Johnson, A.H., 1995. Patterns of nutrient loss from unpolluted, old-growth temperate forests: Evaluation of biogeochemical theory. *Ecology*, 76: 493–509.
- Kertész, Á., Centeri, Cs., 2006. Hungary. In: Boardman, J., Poesen, J. (eds) *Soil erosion in Europe*. John Wiley & Sons, Ltd, London, p. 139-153.
- Pottýondy, Á., Centeri, Cs., Bodnár, Á., Balogh, Á., Penksza, K., 2007. Comparison of erosion, soil and vegetation relation of extensive Pannonian meadows under Mediterranean and Sub-Mediterranean effects. *Cereal Research Communications* 35 (2 PART II): 949-952.
- Várallyay, Gy., 2007. Soil resilience (Is soil a renewable natural resource?). *Cereal Research Communications*. 35 (2): 1277-1280.
- Visser S.M., Sterk G., 2007. Nutrient dynamics - Wind and water erosion at the village scale in the sahel. *Land Degradation & Development*, 18 (5): 578-588.

<http://www.nrcs.usda.gov/TECHNICAL/NRI/ceap/croplandreport/>